Effect of water vapour on neutron detection of cosmic rays

Supawit Kittipadakul[1], Kritpong Kulthamrongsri[1], Wattanapol Sangpho[1], Thawatchai Sudjai[1], and David Ruffolo[2]

[1]Department of Physics, Mahidol Wittayanusorn School, Nakhon Pathom, 73170, Thailand

[2]Space Physics and Energetic Particles Group, Department of Physics, Faculty of Science, Mahidol University, Bangkok, 10400, Thailand

Abstract

Cosmic rays play an important role in our daily lives and can be used in various fields of educational research, especially in physics and astrophysics. However, the detection of cosmic rays is affected by many factors, and atmospheric water vapour pressure was recently suspected to be an important factor. Princess Sirindhorn Neutron Monitor (PSNM) is a cosmic ray detector at Doi Inthanon, Thailand's highest mountain, and the count rate of nearby bare counters relative to PSNM showed a strong anti-correlation with atmospheric water vapour pressure data. It is not clear whether this anti-correlation is a direct effect of water vapour or an indirect effect due to water accumulation on concrete around PSNM. Such an anti-correlation was, therefore, searched with the count rate from a bare neutron counter (MicroMonitor) at Mahidol University in Bangkok. MicroMonitor is in a building; the indirect effect should not be found, but a direct effect would be. Raw count rate and atmospheric pressure data from several years of MicroMonitor operation were processed, normalised with the pressure-corrected PSNM count rate, and searched for a correlation with atmospheric water vapour pressure data at Bangkok. The results were compared with those for PSNM. The neutron detection data at Mahidol University were found that they fluctuate much less and do not exhibit a direct effect of atmospheric water vapour. Consequently, it was concluded that the neutrons detected by bare counters can be indirectly affected by atmospheric water vapour as a proxy for accumulated water which absorbs low energy neutrons.

Introduction

The majority of cosmic ray detectors are placed on the ground, which is probably wet or moist. Before cosmic rays can be detected, they have to travel through atmosphere of the earth; a number of factors influence the amount of cosmic rays. Water accumulated around the detectors is found to have an impact to neutron detection of cosmic rays. It is essential to avoid the effect from accumulated water by locating the detector in the room with certain dry floor.

Objectives

To improve the accuracy of neutron detection of cosmic rays, the examination of the actual effect of atmospheric water vapour pressure is initiated. The objective of this study is to examine the real cause of the effect related to atmospheric water vapour pressure on neutron detection of cosmic rays. To state it in another way, the objective of this study is to test whether atmospheric water vapour pressure affects neutron detection directly or not.

Methods

Reviewing of previous Results
- Studied previous results and found that atmospheric water vapour pressure data have a significant anti-correlation with neutron data from MicroMonitor.

Data Collection
- Collected neutron count rate data from PSNM (from onlinedatabase) and MicroMonitor (from the personal computer).
- Downloaded, extracted, interpolated, and calculated atmospheric water vapour pressure data from Global Data Assimilation System (GDAS).

Data Cleaning
- Corrected neutron count rate data with pressure.
- Eliminated obvious error data.
- Organised and calculated the rest of raw data.

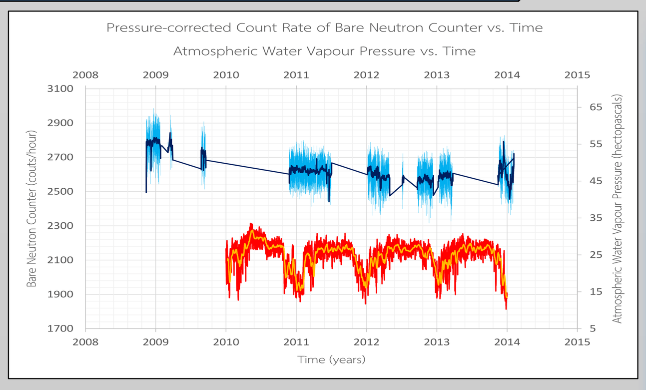
Graph Plotting
- Plotted the processed data vs. time.
- Added trend lines using moving average with the period of 72 data.

Data Analysis
- Compared trend lines of data in each place.
- Compared variations of neutron count rate data from two places.

Conclusion
- Interpreted the analysed data.
- Summarised the contributing cause of the effect of atmospheric water vapour pressure.

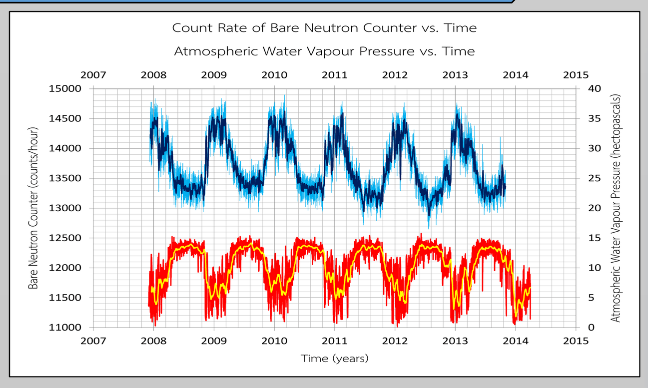
Results and Discussions

At Mahidol University

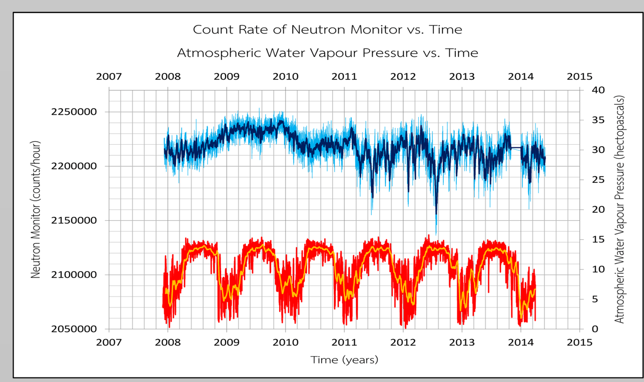


The graph does not show any anti-correlation. Neutron count rates of bare neutron counter have the average variation of 2.26% during the considered period; the fluctuation is too weak to be considered.

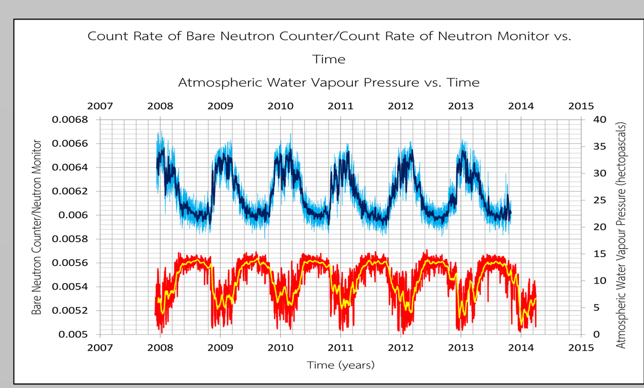
At Doi Inthanon



As shown in the graph, neutron count rates of bare neutron counter periodically fluctuate with the average variation of 14.04%. There is a strong anti-correlation.



Neutron count rates of neutron monitor fluctuate because of the solar cycle; neutron count rate data do not significantly relate to atmospheric water vapour pressure data.



After lessened the effect of the solar cycle by dividing by the amount of high energy neutrons, referring to the amount of cosmic rays, the data—neutron count rates of bare neutron counter divided by neutron count rates of neutron monitor—still show a strong anti-correlation.

Conclusions

Since the variation of neutron count rate data of MicroMonitor is at the rate of 2.26%, and the variation of neutron count rate of PSNM is at the rate of 14.04%, it can be obviously seen that neutron count rate data of MicroMonitor are quite stable. It can be, therefore, concluded that low energy neutrons are affected by water accumulation around the detectors.

Suggestions

- ❖Make sure that the detectors operate accurately all the time.
- ❖Verify data using more than one detector.
- ❖Find data from both neutron monitors and bare neutron counters in the same place.
- ❖Use several data analysing programs.
- ❖For more accuracy, analyse the data from more locations with longer durations.

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